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I, LEANNE MYNOTT, MANAGER EXAMINATION SUPPORT AND SALES hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. 2003904272 for a patent by GRAEME K. ROBERTSON as filed on 12 August 2003.



WITNESS my hand this  
Twentieth day of August 2004

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## PROVISIONAL SPECIFICATION

Invention Title: **Suspension system adaptable as a shock absorber**

The Invention is described in the following statement:

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## SUSPENSION SYSTEM ADAPTABLE AS A SHOCK ABSORBER

### Field of the Invention

The present invention relates generally to suspension units and/or suspension systems, particularly adapted for but not exclusively for use with, 5 vehicles or the like, including vehicles which travel along sealed roads and vehicles which travel off-road such as for example, off-road racing vehicles. The suspension system or unit is also adapted for use in industrial applications, such as for example, industrial switch gear applications, suspension systems for seats, particularly vehicle seats, truck cab suspensions or the like.

10 More particularly, the present invention relates to vehicle suspension units of the combined gas and liquid type having a moveable piston.

Even more particularly, the present invention relates to oleo-pneumatic suspension systems having a reservoir or accumulator for storing or holding fluid, such as hydraulic oil, silicone oil or similar, under gas pressure, in fluid 15 communication with a motion damping device having a valve arrangement or similar so that the fluid is continually being transferred between the accumulator and the motion damping device in response to movement of the road wheel of the vehicle with which the unit is associated in use of the vehicle. The suspension uses gas under pressure to provide the unit with resilience and to effect controlled 20 rebound of the suspension components and the control movement of the road wheel. The present invention also finds application in a compact suspension unit having a single unit which is a motion damping unit for use in a wide variety of vehicles extending from motorcycles through to more or less conventional vehicles for normal road use and four wheel drive vehicles to specialist vehicles such as 25 military vehicles and industrial vehicles.

Although the present invention will be described with particular reference to different forms of suspension system it is to be noted that the present invention is not limited in scope to the described embodiments but rather the scope of the

present invention is more extensive so as to include other components and arrangements of the suspension system and other uses than the specific embodiments described, including applications other than adjusting the spatial arrangement of two moveable members and controlling their movement relative to each other.

- 5
- ### Background Art
- One problem associated with vehicles crossing rough terrain is the amount of travel required of the suspension system. Unless virtually unlimited travel of the suspension system is provided which is impracticable, when the suspension system reaches its limit of travel there will be contact of one component against another component which produces a jolting ride and ultimately fatigue of the components contacting each other as well as loss of traction and less control of the vehicle.
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- In many applications it is desirable to have a more supple suspension even though the vehicle is used in a harsh environment. In these applications not only must the suspension components be durable and reliable but the ride must also be substantially smooth or at least the suspension must not reach the limits of its travel or "bottom out". Therefore, it is one aim of the present invention to provide a suspension system or unit which can be used in harsh environments such as 15
- 20

- rough terrain and which provides a supple ride.
- In other applications, such as for example, in normal domestic vehicles of the type which are privately owned or in motor cycles, there is a need for suspensions which occupy a smaller space within the confines of the car, bike or similar and yet work at least as effectively as more conventional suspensions in ordinary everyday driving. Thus, there is a need for a more compact suspension unit which occupies less room on or within a vehicle and also provides acceptable ride and comfort, which suspension unit can be adapted for use in normal road going cars.
- 25

**Summary of the Invention**

According to one aspect of the present invention there is provided a motion damping suspension unit adaptable for use as a shock absorber including an accumulator for holding and maintaining a fluid under pressure. The accumulator 5 has a floating piston that sealingly separates a first cavity for storing a pressurised gas and a second cavity for storing a fluid under pressure, and a motion damping means that is fluid-filled in operation and in fluid flow communication with the second cavity of the accumulator. The motion damping means has a pair of relatively moveable parts and valve means permitting flow of fluid between the 10 parts. These parts are capable of relative retracting and extending movement during which fluid is forced through the valve means at respective predetermined controlled rates so as to dampen the movement. The movement is such that when the parts relatively extend, fluid is caused to flow from the second cavity of the 15 accumulator to the damping means, whereby gas pressure in the first cavity moves the floating piston in the accumulator to reduce the gas pressure in the first cavity, and when the parts relatively retract, fluid is caused to flow from the damping means to the second cavity of the accumulator, whereby to move the floating piston to increase the gas pressure of the gas in the first cavity. The relatively moveable parts contain respective chambers for the fluid and comprise a 20 first part and a second part in which the first part is receivable, the chamber of the first part being in fluid flow communication with the second cavity.

The first part is sufficiently smaller in cross-section than the second part to define an intermediate chamber about the first part within the second part. The flows at respective predetermined controlled rates are directly from the primary 25 chamber of the first part to the primary chamber of the second part and at least via the intermediate chamber from the primary chamber of the second part to the primary chamber of the first part.

In one application, the first part is substantially smaller in cross-section than said second part whereby said motion damping suspension system is functional 30 as a shock absorber, and wherein said flows at respective predetermined

controlled rates are directly from the primary chamber of the first part to the primary chamber of the second part and via said intermediate chamber from the primary chamber of the second part to the primary chamber of the first part.

- In another application, the flow at a predetermined controlled rate during
- 5 said retracting movement is in part directly from the primary chamber of the second part to the primary chamber of the first part, and also in part indirectly therebetween via said intermediate chamber.

Lateral port means may communicate the intermediate chamber and the primary chamber of the first part.

- 10 The motion damping suspension system may include respective sets of shims or similar in part determining said respective predetermined controlled rates of flow.

Typically, said first and second parts comprise telescopically interengaged tubes respectively of relatively smaller and larger diameter.

- 15 Advantageously, said valve means is provided in a valve body fixed at an inner end of the tube comprising said first part.

- Typically, the suspension unit is a compact unit, preferably adapted for use with motorcycles, particularly off-road or all terrain motorcycles, racing motorcycles and with conventional road going cars or the like. Preferably, said first
- 20 part and said accumulator are integral whereby said second cavity and said primary chamber of the first part comprise a single chamber. Typically, said first part and said accumulator are provided by a single tube.

- Alternatively, said accumulator and said motion damping means are separate units and a conduit is provided for said fluid flow communication between
- 25 the primary chamber of said first part and said second cavity.

Advantageously, the combined volume of the first and second cavities of the accumulator remains constant, irrespective of the position or movement of said floating piston axially along the accumulator.

- Typically, the valve means is a flooder valve or similar valve allowing fluid to
- 5 flow through the valve in two different directions.

Preferably, the difference in volume of the motion damping means at predetermined retracted and extended positions of said parts is substantially the same as the change in volume of the second cavity of the accumulator between said positions.

- 10 Typically, the first cavity of the accumulator is a gas filled chamber in which gas is stored under pressure. The gas may be, eg., air, nitrogen, oxygen, inert gas or the like including combinations and mixtures thereof. The first cavity of the accumulator is preferably provided with a gas valve allowing gas to be admitted to or withdrawn from the accumulator. The accumulator can be pressurised to any
- 15 suitable pressure as predetermined by the particular application. The pressure can vary from a very low pressure such as less than 20 psi to a very high pressure. The predetermined pressure can range, for example, from less than 20 psi to excess of 2000 psi. However, lower pressures can be used in applications such as push bikes, motorcycles and other light weight vehicles whereas pressures of
- 20 about 200 psi can be used for heavy duty vehicles and higher pressures for specialised vehicles. The gas pressure in the accumulator is conveniently adjustable to any value in accordance with requirements of the vehicle to which the suspension unit of the present invention is fitted depending upon the size of the vehicle, the type of vehicle, the intended use of the vehicle, the ride height of
- 25 the vehicle, and the speed of which the vehicle is driven and other similar variables.

The suspension unit may be used as a shock absorber or may perform the same as or a similar function to a shock absorber and has a shaft diameter appropriate to be able to replace a conventional shock absorber in a suspension

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system. The flow of fluid in the damping means in one direction is controlled at a first rate and the flow of fluid in a second direction is controlled at a second rate. The first rate can be the same as or different to the second rate, one rate is associated with compression of the damping means whereas the other rate is 5 associated with extension of the damping means.

The motion damping means may be provided with bypass passages, conduits, tubes, tubing, or similar interconnecting the sides of the unit to provide variable valving for different rates of movement in the damping means, depending upon the position of the floating piston. Typically, the by-pass passages are 10 located externally of the damping unit. Adjustment of the variable rates is conveniently from outside the damping unit by adjusting the flow of fluid through the by-pass passages.

The components making up the suspension system are preferably low friction, such as by being coated with a Teflon coating or similar.

15 The suspension unit may include cooling means for reducing the temperature of the system during operation.

The unit may further include a removable, replaceable, interchangeable canister or other container for varying the gas capacity of the system, or for varying the pressure under which the system operates due to the pressurised gas.

20 The suspension unit may include a gas-chargeable chamber of selectively variable pressure, for use in adjusting the at rest separation of the first and second parts.

**Brief Description of the Drawing**

The present invention will now be described by way of example with 25 reference to the accompanying drawing which is a fragmentary cross-sectional view of a first embodiment of integrated suspension system according to the

present invention having characteristics that make it suitable for use as a shock absorber.

### **Embodiments of the Invention**

In the embodiment of Figure 1, an accumulator and the damping means are contained within a single component in which the accumulator is formed from a first tubular member telescopically located within a second tubular member which is the damping means, the two tubular members being connected together in collinear arrangement and being in fluid communication with each other. The accumulator is sealingly connected to the damping means. This compact arrangement allows flexibility for fitting to standard motor vehicles, motorcycles, trucks, cab suspensions, seat suspensions or the like, typically as a shock absorber.

Combined component 110 has a first cylindrical tube 112 which is the accumulator received within a second cylindrical tube 114. Tube 112 is connected to tube 114 through an end cap 182 that includes a sealing configuration 117 about tube 112 and a secure fastening to the end of tube 114.

Tube 112 is provided, in this case at the outboard or proximal end, with a filling valve 118 for introducing gas, such as nitrogen or similar, under pressure into accumulator tube 112 to fill a first cavity or chamber 120 located at or towards the proximal end of tube 112 for storing gas under pressure. A double sided floating piston 122 is provided intermediate the two ends of accumulator tube 112. The first chamber 120 is formed between filling valve 118 and piston 122. A second chamber 124 is formed between piston 122 and the inboard end or distal end of tube 112. Hydraulic fluid fills the second chamber 124 of accumulator 112.

A double acting valve arrangement 126 is provided in a valve body 125 at or towards the inboard end or distal end of accumulator tube 112. Valve body 125 slidably engages the interior of tube 114 and separates chamber 124 from larger chamber 129 within tube 114. Valve body 125 moves through the hydraulic fluid or

the hydraulic fluid moves through it in accordance with corresponding movement of tube 112 depending on whether the valve body 125 is fixed or free to move. Preferably, the valve arrangement is fixed about the end of tube 112 by transverse fastening screws 127.

- 5        Tube 112 is substantially smaller in cross-section than tube 114 so that an intermediate variable-volume annular chamber 152 is provided within tube 114 and about tube 112 between end-cap 182 and valve body 125. Fluid communication between chamber 124 and chamber 152 is provided by a ring of bleed ports 156 displaced axially from valve body 125.
- 10      The individual valving of valve arrangement 126 is such to allow fluid to flow in one direction at one rate when tube 112 moves in a first axial direction and to flow in the opposite direction at a second rate when tube 112 moves in the opposite direction. The rate of movement of fluid through the valving is dependent on the number, size and arrangement of the apertures, ports or passageways, and
- 15      on the flow control elements, in this case shims 154, 155 forming the individual valving within valve arrangement 126.

More specifically, when the tubes 112, 114 relatively retract, i.e., during compression, fluid is forced into chamber 152 via a ring of outer ducts 150 adjacent the periphery of valve body 125. On extension or rebound, an annular 20 non-return shim set 154 closes ducts 150, fluid in chamber 152 is bled through ports 156, and fluid flows from chamber 124 into chamber 129 via a ring of oblique ports 153 of valve arrangement 126, controlled by shims 155. In other embodiments, shims 154, 155 may be substituted by other forms of one-way valve, eg. ball valves.

- 25      When end cap 182 passes ports 156, the residual fluid in chamber 152 cushions the further relative motion of tubes 112, 114, and thereby provides hydraulic top-out.

- Both ends of combined component 110 are provided with suitable fittings to enable this component to be located in place as part of the suspension system of a motor vehicle. It is to be noted that any suitable fitting can be provided at either or both ends of this form of the component: exemplary fittings are illustrated.
- 5     necessary or desirable, tubes 112, 114 can be provided with outer cooling jackets for receiving recycled coolant to cool component 110 in use. Additionally or alternatively, the outer surface of damping tube 114 is provided with removable, replaceable and/or interchangeable air cooling fins locatable around the outside of the outer wall of tube 114 for increased cooling if required.
- 10    In operation of this form of the suspension system the outboard end of damping tube 114 is fixedly located to suspension components of the wheel of a motor vehicle or to another component which is connected either directly or indirectly to one road wheel of the vehicle, so as to act as a shock absorber for the suspension component. Thus, tube 114 moves in accordance with substantially vertical movement of the wheel over bumpy or rough terrain or the like. The outboard end of accumulator tube 112 is connected to the body work of the motor vehicle or other fixed component and is thus fixed in place.
- In operation when a road wheel encounters a bump in the form of a crest or rise or similar, damping tube 114 is forced by the suspension of the wheel towards
- 20    accumulator tube 112 so that the length of the combined component 110 is reduced. In turn, the inboard end of tube 112 is forced further into the body of tube 114 thereby pumping hydraulic fluid from within tube 114 through valve arrangement 126 into chamber 124 provided between the inboard surface of piston 122 and valve arrangement 126. As the volume of fluid being forced into
- 25    chamber 124 increases piston 122 travels axially along the inside wall of tube 112 towards the outboard or proximal end of this tube thereby further compressing the gas in chamber 120 and increasing the internal pressure within component 110. This in turn offers increasing resistance to further movement of tube 114 thus limiting the amount of travel of tube 114 which in turn limits the amount of travel of
- 30    the road wheel in a substantially vertically upwards direction.

When the road wheel returns to its normal position, such as for example, when rebounding or when encountering a trough or crest in the road the length of combined unit 110 is increased by tubes 112 and 114 telescopically expanding with respect to each other thereby allowing fluid to move from chamber 124 into 5 tube 114 which reduces the amount of fluid in chamber 124 allowing piston 122 to move under the increased gas pressure of the compressed gas stored in chamber 120 which in turn reduces the compression or gas pressure of the gas in chamber 120. Further fluid is pumped into tube 114 until all of the pressures equilibrate. The rate at which fluid can flow through valve arrangement 126 limits the amount of 10 travel of the road wheel in the substantially vertically downward direction.

In a modification by-pass conduits or similar are provided at spaced apart intervals over the length of the combined conduit. The by-pass conduits which are located external to the body of the unit provide a means of fine tuning the compression and rebound characteristics of the unit. Typically, one, two, three or 15 more by-pass tubes are provided in which a two tube arrangement allows for one adjustment on compression and a different adjustment on rebound while a three tube arrangement allows for two zone adjustment on compression and one zone adjustment on rebound.

Advantages of the present invention include the following. The spring rating 20 characteristics of the system can be easily adjusted by changing the gas-to-fluid volume ratio, eg. by changing gas pressure in the first cavity of the accumulator and/or by fitting different sized canisters.

There are no metal springs or spring components to break or distort.

A flexible and supple ride is provided even though the vehicle is being 25 driven over very rough terrain at very fast speeds.

A compact yet effective suspension system is possible using the present invention.

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**It will be understood that the invention disclosed and defined herein extends to all alternative combinations of two or more of the individual features mentioned or evident from the text or drawings. All of these different combinations constitute various alternative aspects of the invention.**

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**12 August 2003**

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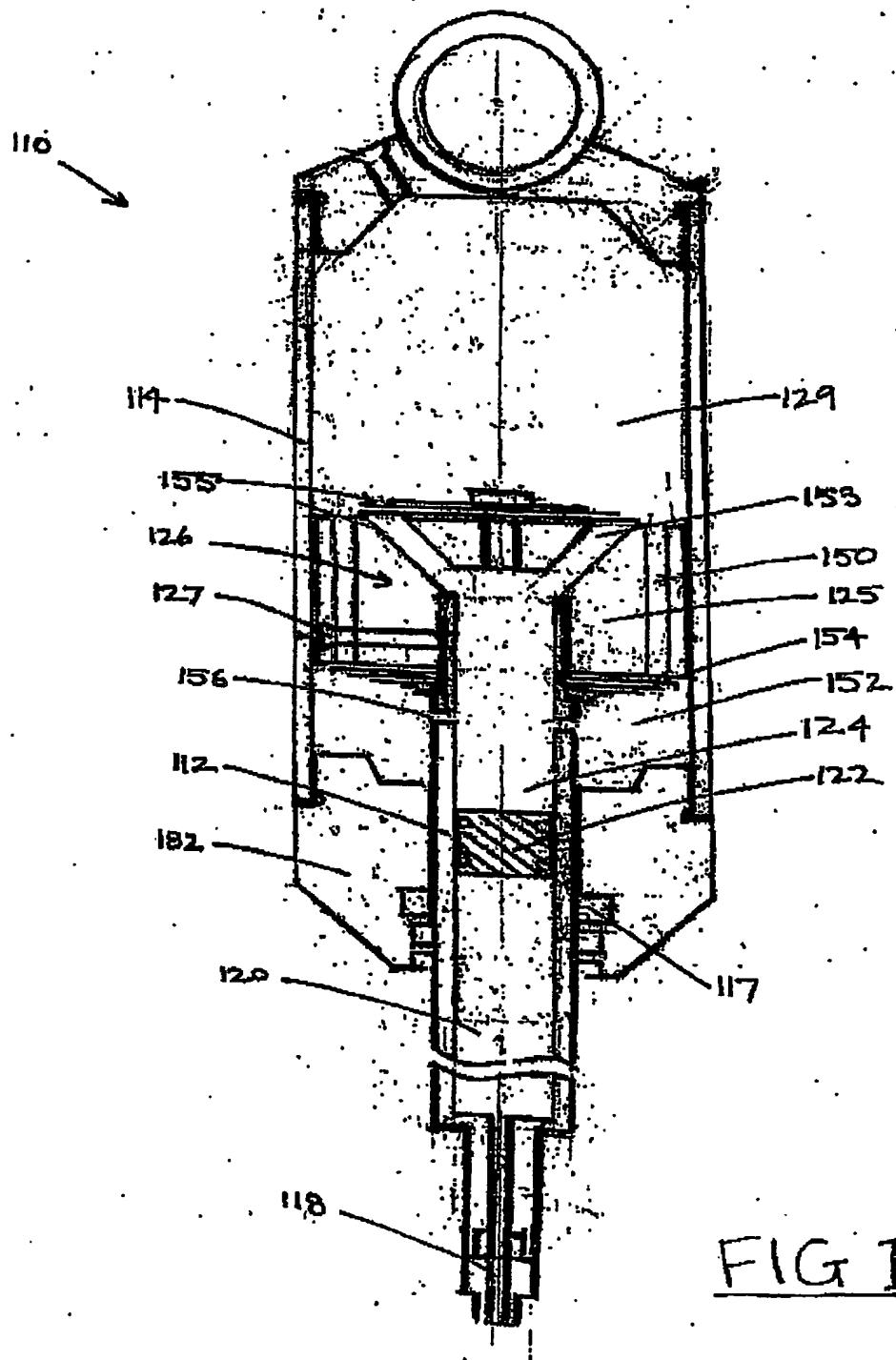


FIG 1

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